RESEARCH DEPARTMENT

THE STEPHENS ELECTROSTATIC MICROPHONE TYPE C-1

Report No. L-027

(1955/24)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

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SUMMARY

Laboratory tests have been carried out on a single specimen of the Stephens Trusonic Microphone, Type C-1, a pressure-operated electrostatic instrument which functions by amplitude-modulating a radio-frequency carrier. Measurements of frequency response, sensitivity, variation of sensitivity with mains voltage, impedance and susceptibility to interference from magnetic fields have been made; the stray radio-frequency field set up by the microphone has also been investigated.

1. INTRODUCTION.

The Stephens Trusonic microphone is of the pressure-operated electrostatic type which amplitude-modulates a radio-frequency carrier generated by a local oscillator. The modulated wave is rectified and an audio-frequency signal thus obtained.

This system of operation is a recent revival of an old device which was introduced about 1928. The Stephens microphone differs however from the earlier versions in that the pressure-sensitive element is separate from the oscillator-demodulator unit to which it is connected by a long thin coaxial cable.

The microphone tested consisted of a type C-1 head used in conjunction with type OD-4 oscillator-demodulator unit.

2. DESCRIPTION OF MICROPHONE.

Fig. 1 shows a photograph of the microphone. The head itself is only 3·8 cm long, the remainder of the assembly consisting of a rather elaborate cable termination on a ball and socket mounting, to which the microphone head is secured by means of the knurled screw shown in the figure.

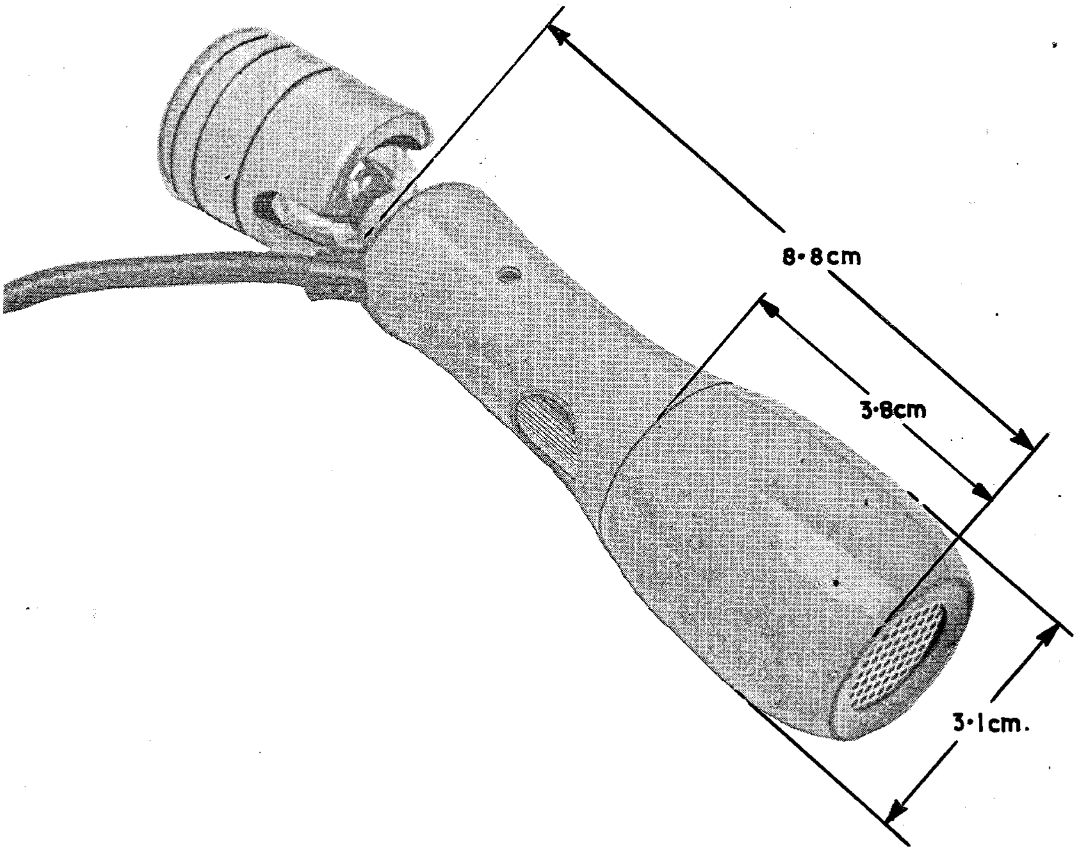


Fig. 1 - Stephens microphone head type C-1

According to the manufacturers' description of the microphone, the capacitance between the diaphragm and the back plate is partially tuned at the carrier frequency——in the present case 8·66 Mc/s——by a small coil located inside the microphone head. It was not possible to dismantle the head to discover the internal connections without destroying the adjustment of the instrument. The impedance of the head, as measured at frequencies up to 150 Mc/s, may be represented by the equivalent circuit shown in Fig. 2. In the absence of more information, it is not possible to tell whether the value of C1 represents the capacitance between diaphragm and back plate, since the circuit may in fact contain a tapped coil which would act as a transformer.

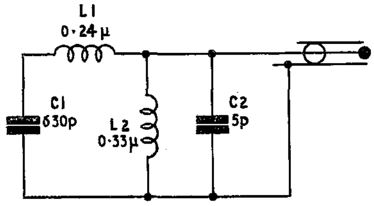
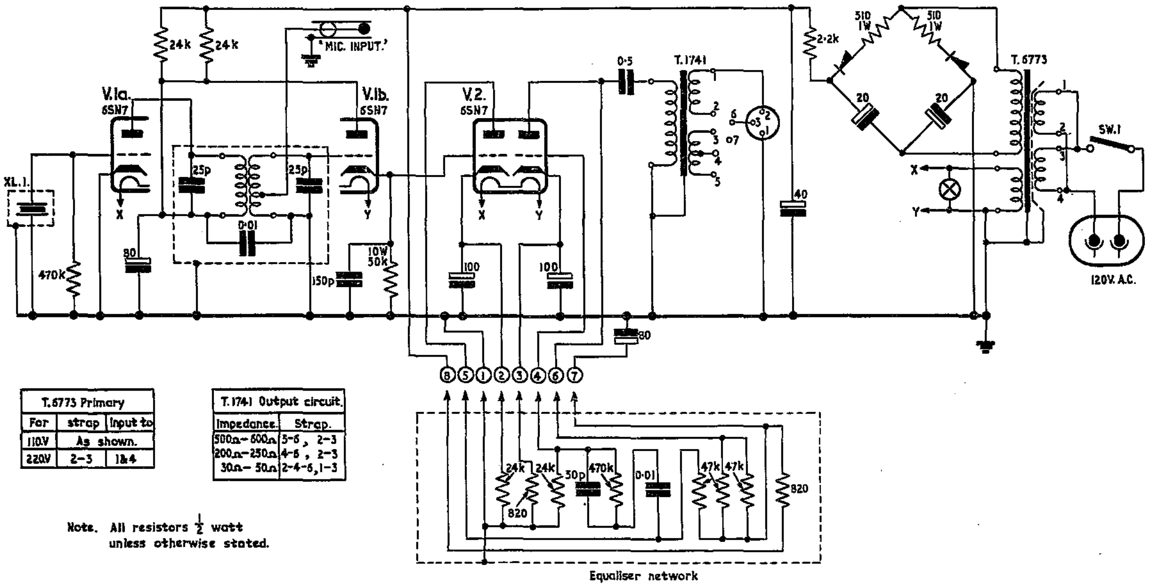


Fig. 2 - Equivalent circuit of microphone head

Fig. 3 shows the circuit diagram of the oscillator-demodulator unit. Valve V1 and the associated crystal form an oscillator, the output from which is coupled to the grid of the demodulator V2 by a tuned transformer. The microphone head is connected across a small portion of the secondary of this transformer through a 15-metre coaxial cable 4 mm in diameter and of 42 ohms characteristic impedance. The cable is made two-thirds of a wavelength long; when the reactance of the head changes as a result of diaphragm deflection, the resistance as well as the reactance presented to the transformer also changes, thus amplitude-modulating the radio-frequency carrier. The length of cable can be increased by adding units of 11·5 metres up to a maximum of 120 metres. These units are equal to half wavelengths and in theory their addition should not affect the operation of the instrument but the manufacturers recommend that the radio-frequency transformer should be retuned.



T.6773 Primary		
For	strap	input to
110V	As shown.	
220V	2–3	1&4

T.1741 Output circuit.	
Impedance.	Strap.
500Ω–600Ω	5–6 , 2–3
200Ω–250Ω	4–6 , 2–3
30Ω– 50Ω	2–4–6, 1–3

Note. All resistors ½ watt unless otherwise stated.

Fig. 3 - Oscillator—demodulator unit type OD-4. Circuit diagram

The response of the microphone proper falls off above 2 kc/s but this loss is corrected in the audio-frequency part of the circuit by an equaliser network shown in Fig. 3. This network, together with valves V3 and V4, forms an equalised amplifier, the output transformer of which is tapped for use with loads of 30 to 50 ohms, 200 to 250 ohms and 500 to 600 ohms. Space is provided for the mounting of additional resistors for the purpose of attenuation or impedance matching.

Fig. 4 shows the frequency response of the equalising amplifier, obtained by applying a constant voltage to the grid of V3 and measuring the open-circuit voltage appearing at the 200 to 250-ohm tap.

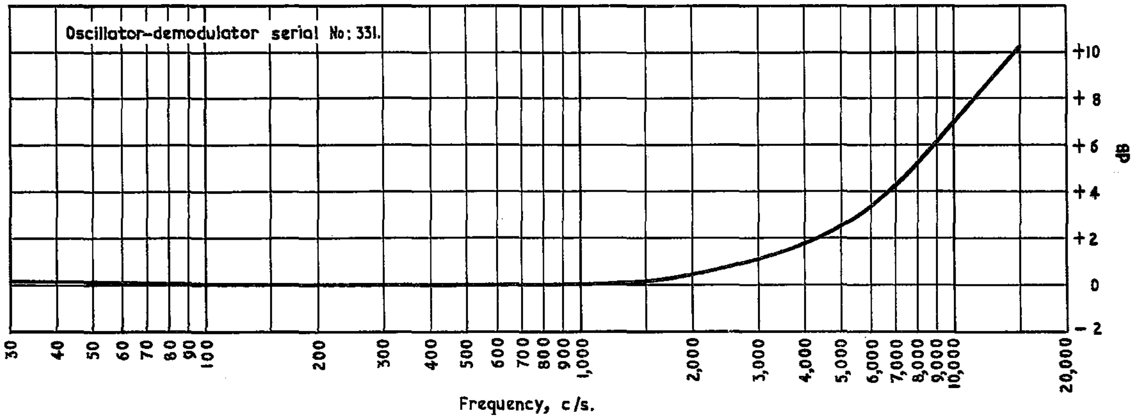


Fig. 4 - Oscillator—demodulator unit equalising amplifier frequency characteristic. 200/250-ohm tap, open circuit

The equipment is a.c. mains operated, the power transformer being tapped for 110 volts or 220 volts.

The weight of the microphone head without cable is 62 gm alone and 162 gm with ball and socket mounting.

The weight of the oscillator-demodulator unit is 3·51 Kg.

3. FREQUENCY CHARACTERISTICS.

Fig. 5 shows the open-circuit frequency characteristics of the microphone for sound incident at angles of 0°, 90° and 180°, while Fig. 6 shows the correction to be applied to these curves to obtain the response into a resistive load of 300 ohms with the output transformer tap set for the 200 to 250-ohm range.

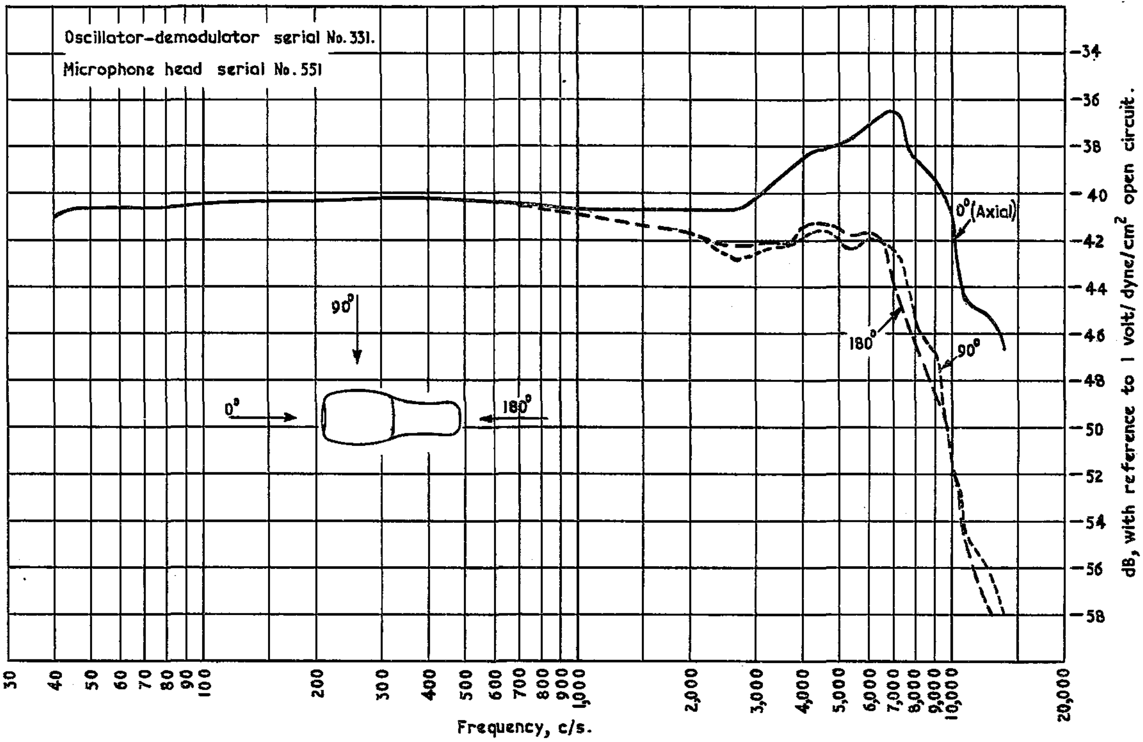


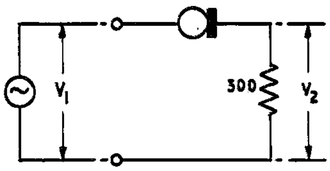
Fig. 5 - Open-circuit frequency characteristics

It will be seen that the response falls off rapidly above 7 kc/s, at which frequency a hump of 4 dB appears in the axial frequency characteristic. The variation in high-frequency response with angle of incidence is consistent with the size and shape of the microphone.

Fig. 7 shows the frequency response curve, presumably for axial incidence, given by the manufacturers.

4. IMPEDANCE.

Fig. 8 shows the variation of microphone impedance with frequency with the output transformer tap set for a 200 to 250-ohm load. It will be seen that the impedance over most of the frequency range is some 60% of the nominal load.



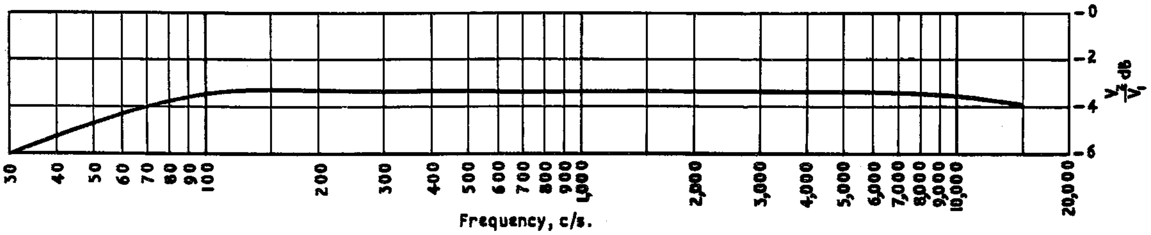


Fig. 6 - Relationship between open-circuit voltage and voltage developed across 300-ohm load using 200/250-ohm tap

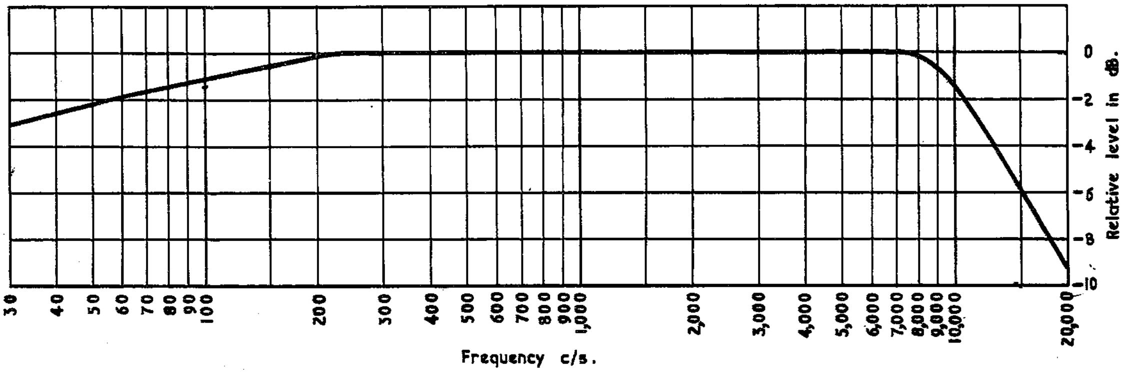


Fig. 7 - Frequency characteristic given by manufacturer

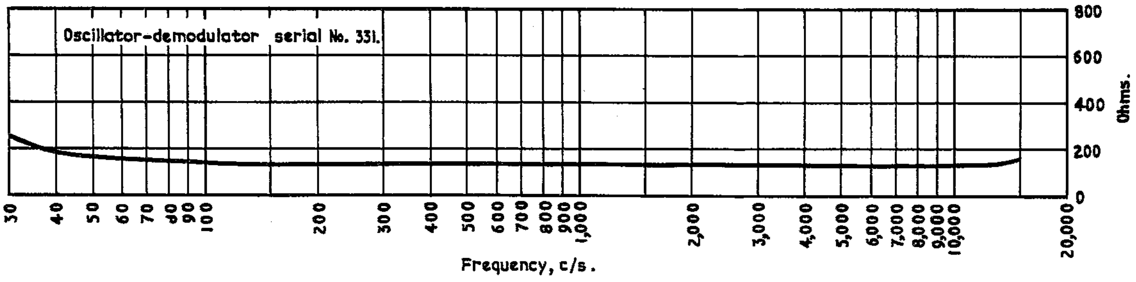


Fig. 8 - Modulus of output impedance using 200/250-ohm tap

5. SENSITIVITY.

The open-circuit sensitivity in the mid-band region is -41 dB with reference to 1 volt/dyne/cm^2 with the output transformer on the 200 to 250-ohm tap. The manufacturers give a maximum sensitivity figure which corresponds to an open-circuit level of -35 dB with reference to 1 volt/dyne/cm^2 on 250 ohms.

With the mains transformer set at 220 volts the sensitivity varied ± 1 dB with mains voltage variations of ± 15%.

6. NOISE.

6.1. General.

The noise output of the microphone is mainly due to the radio-frequency carrier and comes from the oscillator circuit. The r.m.s. open-circuit noise voltage in the band 0 to 10 kc/s is −92 dB when weighted by an aural sensitivity network type ASN/3. The sound level in the mid-band region which would produce a microphone output equal to that due to the weighted noise is + 23 dB relative to 0·0002 dyne/cm^2. For comparison, the corresponding figure for an AXBT microphone is + 18 dB.

6.2. Interference from Magnetic Fields.

The maximum open-circuit voltage induced in the microphone by a uniform magnetic field of 1 milligauss was too small to measure at 50 c/s. At 1 kc/s, the sound level, relative to 2×10^{-4} dyne/cm^2, required to give a signal equal to the induced voltage, was less than −2 dB and at 10 kc/s, less than + 15 dB.

6.3. Microphony from Cable.

Although any change in capacitance of the coaxial cable would necessarily produce some degree of amplitude modulation of the radio-frequency carrier, no serious microphonic effects were observed when the cable was handled or tapped.

7. RADIO INTERFERENCE.

Since a radio-frequency voltage is generated inside the oscillator-demodulator unit, the possibility of interference with neighbouring equipment has to be considered, and the stray field around the microphone was therefore measured.

The field emanating from the oscillator-demodulator unit was approximately 5 μV/m at a distance of 60 cm while a similar field strength was measured at 15 cm from the microphone head.

The manufacturers suggest that if more than one of these microphones is used close to another, the carrier frequencies should be different. To this end up to five alternative crystals can be supplied differing in frequency by steps of 20 kc/s.

8. CONCLUSIONS.

The advantages of the Stephens microphone over electrostatic microphones of conventional type lie in the small size of the pressure-sensitive element, the absence of the usual head amplifiers requiring specially selected valves, and the fact that up to 120 metres of coaxial feeder can be used instead of the usual 10 to 20 metres of multi-core cable.

The sensitivity is extremely high and for normal studio use an internal attenuator would have to be fitted. The signal-to-noise ratio is of the same order as that of most other electrostatic microphones.

The frequency characteristics below 7 kc/s are similar to those of other electrostatic microphones of comparable dimensions, but the response above 10 kc/s drops rapidly.

The radio-frequency field set up is small and interference is unlikely to be encountered except with very sensitive apparatus.